Caisson Placement and Impoundment Material Characterization Impoundment 1 and 2 Pilot Study Operable Unit 8 - American Cyanamid Superfund Site

Prepared for:	Mark Austin/USEPA
Copy to:	Russ Downey/Pfizer Vince D'Aco/Quantum
Prepared by:	CH2M HILL OU8 Project Team
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On behalf of Pfizer Inc., CH2M HILL is supporting the design, construction, and operation of a pilot study program within Impoundment 2 for Operable Unit 8 (OU8) at the American Cyanamid Superfund Site in Bridgewater, New Jersey (Site). This technical memorandum presents a summary of the caisson installation process, including the boring program completed to profile the material prior to caisson installation, the caisson installation process, the lifting program to regain material within the caisson, the additional probing and visual inspection completed after installation, and the proposed path forward for continuation of the pilot testing program.

Pre-Caisson Installation Borings

Prior to the installation of the caissons, a GeoProbe was utilized to perform the clay/tar investigation, as outlined in the workplan (CH2M HILL, May 2013). The primary purpose of the investigation was to evaluate the top of the clay layer and the thickness of clay to determine the length of each caisson prior to installation. Also, profiles were collected from the borings to determine the types of material (viscous rubbery [VR], hard crumby [HC], or a mixture of each [MIX]) within each location. The results of the clay investigation will be reported in a separate technical memorandum.

Three or four borings (depending on the recovery and access) were performed within each of the three caisson locations to determine the types of materials present. The borings from the three locations (caissons #1 through #3) are summarized in Figures 1 through 3, respectively. Note that no recovery was initially interpreted as VR; however as described further below, recovery was low for both VR and MIX materials. A summary of each location is as follows:

- Caisson #1 Location – Prior to installation of the caissons, an average of 4.3 feet of no recovery was seen. This average is based on three of the four boring locations, as the fourth location had no recovery in the entire length of the boring. Below the area of no recovery, an average of 2.9 feet of HC was identified to the bottom of where the caisson was ultimately set.
- Caisson #2 Location – Prior to installation of the caissons, an average of 6.4 feet of no recovery was seen, followed by an average of 1.2 feet of HC to the bottom of where the caisson was ultimately set.
- Caisson #3 Location - Prior to installation of the caissons, an average of 4.4 feet of no recovery was seen, followed by an average of 2.9 feet of HC to the bottom of where the caisson was ultimately set.

Caisson Installation

The three caissons were installed on October 29, 2013. As communicated to EPA in various emails during the week of November 4, 2013, it appeared that the liners in caissons #2 and #3, which were cut prior to the installation of the caissons, did not completely tear when the caissons were installed. This appeared to have caused some of the material in those two caissons to be displaced during the installation. It appeared that caisson #1 did not displace material to any significant extent during installation. A summary of the conditions in each caisson after installation is as follows:

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- Caisson #1 – In caisson 1, the liner appears to have torn as expected and the profile of the material is consistent with the profile seen prior to caisson installation. There is approximately 7 feet of material within the caisson based on the logs completed after installation, which is consistent with the total depth seen prior to caisson installation.
- Caisson #2 – Pieces of the liner were encountered and after manual probing, it was noted that there was only approximately 4 feet of material in the caisson. Based on the original borings, there was 6.4 feet of no recovery (assumed to be predominately VR), and 1.2 feet of HC material. It was difficult to tell through manual field probing if the 4 feet of material was VR, HC, or MIX.
- Caisson #3 – As with caisson 2, there was approximately 4 feet of material in the caisson two days after installation. Remnants of the liner were also found in this caisson. It was difficult to tell through manual field probing if the 4 feet of material was VR, HC, or MIX.

It is believed that the liner in caissons #2 and #3 did not tear when passing through the VR and "pushed" the VR horizontally until the caisson encountered the interface with the VR and HR, which is when the liner tore.

In an effort to restore the materials within caissons #2 and #3 to original conditions, a program to remove the liner, lift the caissons, and allow material to flow back into the caissons was implemented, as outlined in the email provided to EPA on November 4, 2013. The results of those tests are summarized as follows:

- Caisson #2 – After raising the caisson 40 inches from the deck of the Flexifloat platform and allowing to sit overnight, approximately 5 feet of material re-entered the caisson headspace, giving a total thickness of approximately 9 feet. This is thicker than the original material thickness and is believed to have increased because of the hydrostatic head difference between the impoundment water elevation and the lower elevation within the caisson. Based on this, the bottom of the profile in caisson #2 is similar to original conditions, but there is approximately 2 additional feet of material in the caisson (a thickness of approximately 9 feet total).
- Caisson #3 – After raising caisson #3 approximately 58 inches off of the Flexifloat deck, approximately 1 foot of material re-entered the caisson after the first day of recovery. The caisson was lowered, lifted again to approximately 2 feet off the Flexifloat deck, and left in this position over the weekend of November 9-10. On November 11, 2013, the material level was observed to be approximately 7 feet, the same thickness as prior to installation.

During manual probing of the material to measure thickness during the lifting process, it was difficult to distinguish between VR, HC, or MIX. While resistance was encountered at different depth intervals, a definitive determination could not be made.

Post-Caisson Installation Investigation

After completion of the lifting to promote material to move back into the caissons, a GeoProbe was utilized again to collect profiles from the location as performed previously.

Two to four locations were probed within each of the three caissons to determine the types of materials present. The borings from each of the three locations (caissons #1 through #3) are summarized in Figures 1 through 3, respectively. A summary of each location is as follows:

- Caisson #1 – After caissons installation, an average of 3.7 feet of no recovery was seen. Below the area of no recovery, an average of 3.4 feet of HC was identified to the bottom of the caisson. These thicknesses were consistent with the thicknesses seen prior to installation (4.3 feet of no recovery and 2.9 feet of HC). It should be noted that the tar depth was approximately six inches thicker when the original measurements were collected, but were near the same elevation when visual inspection was completed as documented below.
- Caisson #2 – After caisson installation, approximately 4.3 feet of no recovery was seen, followed by a thin lens of HC, which averaged 0.8 feet in thickness (and varied between 1 inch and 1.6 feet thick). Below the lens of HC, an average of 2.6 feet of no recovery was seen, followed by an average of 2.0 feet of HC to the bottom of the caisson. The thickness of HC seen at the bottom of the caisson was consistent with pre-

caisson installation (1.2 feet on average prior to installation and 2.0 feet average after installation). Besides the thin lens of HC, the thickness of no recovery was consistent with pre-caisson installation borings. Note that there was approximately 2 feet of additional material in this caisson after performing the lifting program.

- Caisson #3 – After caisson installation, an average of 4.7 feet of no recovery was seen. Below the area of no recovery, an average of 2.5 feet of HC was identified to the bottom of the caisson. These thicknesses were consistent with the thicknesses seen prior to installation (4.4 feet of no recovery and 2.9 feet of HC).

When reviewing the pre- and post-caisson installation logs, if appears that the profiles were similar before and after caisson installation. However, the types of materials in the shallow intervals in all caissons were not characterized, due to the limited recovery during installation. Therefore, based on discussions with EPA on November 14, 2013 and documented in an email that day, a visual inspection of the top three feet of material was performed on November 15, 2013 to inspect the types of material in the shallow depths of each caisson. The procedures that were followed during this test were as follows:

- Prior to the testing, ambient air readings were collected immediately surrounding the caissons, immediately downwind of the caisson on the platform, and in the center berm of the impoundments (downwind on the day of testing).
- A bucket excavator was used to collect material from within the caissons. Two excavator buckets were removed; one from the shallow interval approximately 0-1.5 feet into the material and the second from 1.5 to 3 feet into the material.
- The bucket was then slowly raised within each caisson while PID measurements were collected as discussed above.
- The bucket was raised to the top of the caisson (not out of the caisson) for visual inspection; PID readings were collected as outlined above during the process.
- The materials were then lowered back into the caisson and the bucket was raised and cleaned prior to removal.

The results of the visual inspection of each caisson are illustrated on Figures 1 through 3 and are as follows:

- Caisson #1 – The material from 0.0-1.5 feet was VR; and the material from 1.5-3.0 feet was MIX.
- Caisson #2 – The material from 0.0-1.5 feet was VR; and the material from 1.5-3.0 feet was MIX.
- Caisson #3 – The entire profile from 0 to 3 feet was MIX.

Based on these observations, the areas of no recovery are not consistently VR material only, but in some areas are mixes of VR and HC. It should be noted that during the 2010 OBG investigation, borings performed in this area were also designated as a mix of VR and HC from the surface to the tar to approximately 5 feet deep.

When comparing the percentage of VR, HC, MIX in the three caissons after caisson installation to the average distribution of each material in the two impoundments as determined from the 30 borings obtained by OBG in 2010, the following is the mean fraction of the contents of both impoundments compared to the material in the three pilot test caissons.

	Mean Fraction of Each Type, %			
	VR	**MIX**	**HC**	**OTHER**
Impoundments 1 and 2	17	32	44	7
Caisson #1	22	26	52	0
Caisson #2	16	55	29	0
Caisson #3	0	65	35	0

Note that other materials (e.g. clay, sand, etc.) were observed by OBG in Impoundment 1 during the 2010 study; these other materials are not present within the caissons.

Assuming that the MIX material is 50% VR and 50% HC, the materials in the three caissons are quite similar to the average distribution throughout Impoundments 1 and 2, except that caisson #2 has a slightly greater quantity of VR (see table below). As noted earlier physical characteristics may vary between HC and VR, however the chemistry and heat value are similar.

	Mean Fraction of Each Type, %		
	VR	**HC**	**OTHER**
Impoundments 1 and 2	33	60	7
Caisson #1	35	65	0
Caisson #2	43	57	0
Caisson #3	33	67	0

As a result of these investigations, the make-up of the acid tar (e.g. VR, HC, etc.) after installation of the caissons and prior to treatment is known. This information will be useful in interpreting the pilot results and extrapolating to other areas in the Impoundments.

Pilot Test Objectives and Material Profiles

The overall objectives of the OU8 pilot study are to 1) collect data on in-situ thermal treatment (ISTT) and in-situ stabilization/solidification (ISS) to evaluate the effectiveness of these technologies for full scale operations, and 2) to evaluate the implementability of these technologies in-situ. As described in the 100% Design Report, the treatment plan is ISS only in caisson #1, ISTT only in caisson #2, and ISTT followed by ISS in caisson #3.

Based on borings completed by OBG in the two impoundments, varying combinations of VR, HC, and MIX will be encountered when performing full-scale remediation. The results of the pilot test, along with the results of the laboratory testing, will allow for the extrapolation of that data to develop alternatives within the Focused Feasibility Study (FFS). Some examples of the results that will be obtained and how they will be utilized to determine the effectiveness of the technologies are:

- As seen from samples of VR and HC previously, the chemical composition is very similar. Therefore, the mixture of materials in the caissons should not limit the effectiveness of reducing the volume or mobility through treatment, either for ISTT or ISS.
- Based on the results of the laboratory testing, it is expected that the physical characteristics of the material will vary after ISTT based on the mixture of VR or HC. In the laboratory, high compressive strengths were seen of the HC material after thermal treatment and low compressive strengths were seen of the VR. Based on the plan for thermal treatment in caissons #2 and #3, useful information on the different compressive strengths will be collected based on the different volumes of the types of materials seen between the caissons. In caisson #2, there is a definitive layer of VR, a mix of both materials, and HC at the bottom of the caisson. This differs from caisson #3, which has only a mix of material and a thicker layer of HC when compared to caisson #2. This data will be useful in understanding the differences in compressive strength after thermal treatment of materials with different VR versus HC mixes and will be extrapolated to other conditions over the impoundments.
- For ISTT, useful data will also be collected for total VOC removal, material heating and cooling time, and VOC removal over time due to the different volumes of tar between caissons #2 and #3. This information will aid in determining how ISTT could be scaled to larger in-situ cells, if ISTT is ultimately a part of the chosen alternative.
- For ISS, the different types of material seen between caissons #1 and #3 will provide useful data in determining if different compressive strengths are seen with different types of mixtures. Caisson #1 has a definitive layer of VR over a layer of HC; while caisson #3 has a layer of MIX over a layer of HC.

The results of this pilot test combined with the laboratory testing results will provide a comprehensive data set to develop alternatives within the FFS. It is acknowledged that the material within the three caissons cannot represent the conditions seen in every location over both Impoundment 1 and 2, and that the results of the pilot test may show that additional laboratory testing would be required to fill data gaps for different mixtures of materials, primarily the physical characteristics after treatment.

Significant data will be collected to determine the implementability of these technologies at full-scale. Some examples of data to be collected are:

- The mass flux in the vapor stream is an important data point in determining the viability of these technologies full-scale. The VOC and sulfur-bearing compounds seen during the pilot test (including concentrations over time, cumulative concentrations over the entire pilot, and individual compounds) are important in understanding the amount of material that could be safely treated at any one time full-scale.
- The effectiveness of ISTT with limited heating at the bottom of the impoundments (required to protect the clay layer and minimize potential groundwater impacts) will be evaluated. It is acknowledged that during the pilot test, the bottom profile of tar within the ISTT caissons may not be treated as effectively as shallower horizons.
- Condensate will be collected to determine 1) the types of condensate that may be generated full-scale, and 2) available options for the ultimate deposition of these materials.
- A corrosion study is included in the pilot to evaluate the materials of construction that could be used for any operation full-scale.
- At the end of the pilot test, the caissons will be removed, decontaminated, and disposed of off-site. This information will be useful in determining how to perform these procedures during a full-scale operation.

The objectives of ISTT and ISS for the OU8 pilot test were outlined in Tables 3-2 and 3-3 of the 100% Design Report, respectively. The materials within the three caissons will meet the ISTT objectives outlined in Table 3.2, some of which are demonstrating efficacy of ISTT, heater well installation methods, heat losses during ISTT, vapor recovery methods and effectiveness, effluent treatment, collection, and disposal options for condensate, and alternatives for handling and treating the tar material. The objectives for ISS, some of which are determining the feasibility and efficacy of homogenization, pH adjustment, and in-situ stabilization, options for handling and recovery of vapors during ISS, and disposal options for the tar material, will be met with the materials within the three caissons. The verification parameters outlined in Table 3-4 of the 100% Design Report, such as air monitoring, compressive strength, condensate generations/properties, temperature, air composition and emissions, and residuals management will be obtained using the OU8 pilot test to support the Focused Feasibility Study (FFS).

Figure 1

Caisson 1 Profile - Pre- and Post-Caisson Installation Summary
American Cyanamid Superfund Site
OU8 Pilot Testing

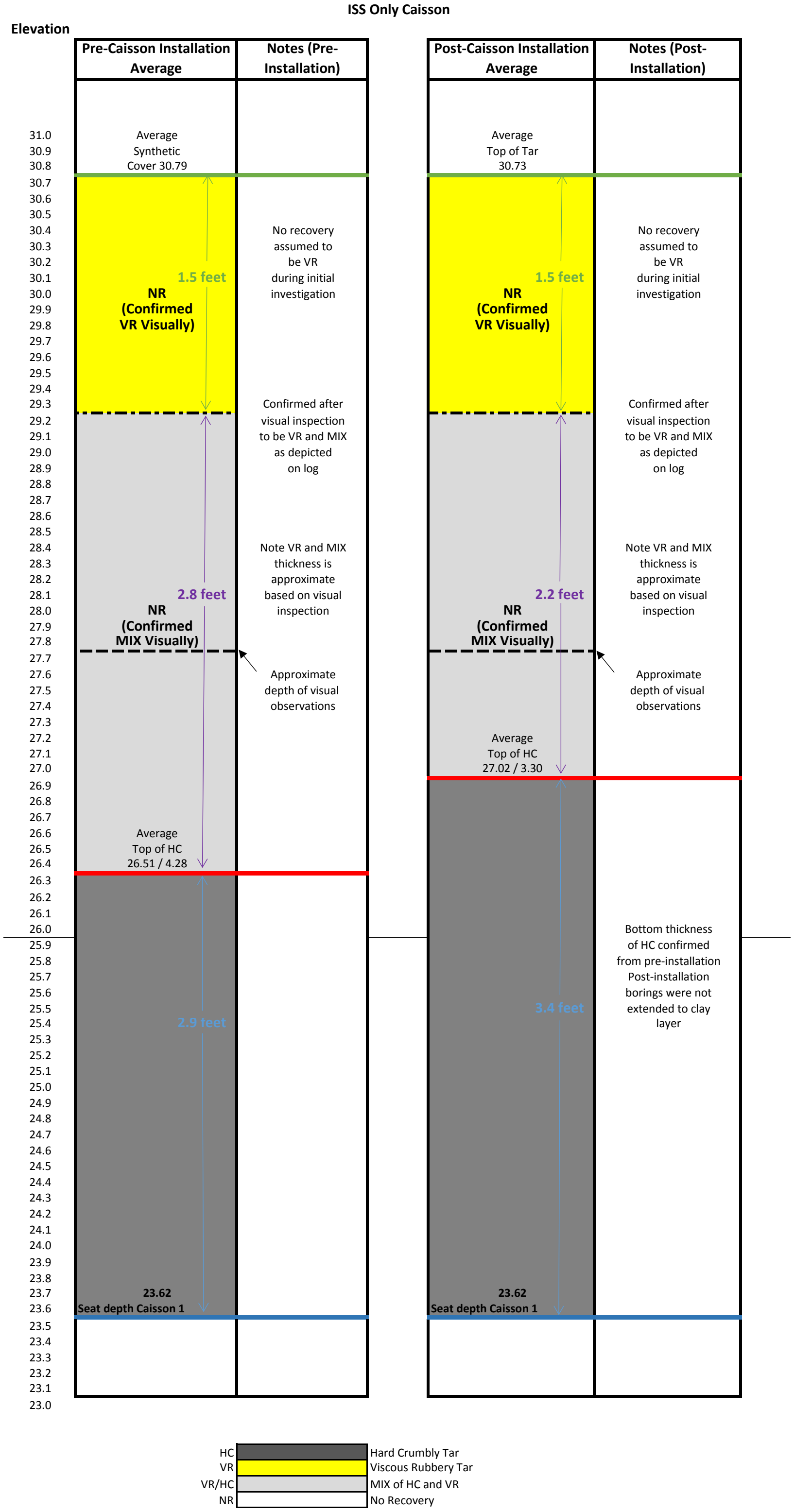

Figure 2

Caisson 2 Profile - Pre- and Post-Caisson Installation Summary
American Cyanamid Superfund Site
OU8 Pilot Testing

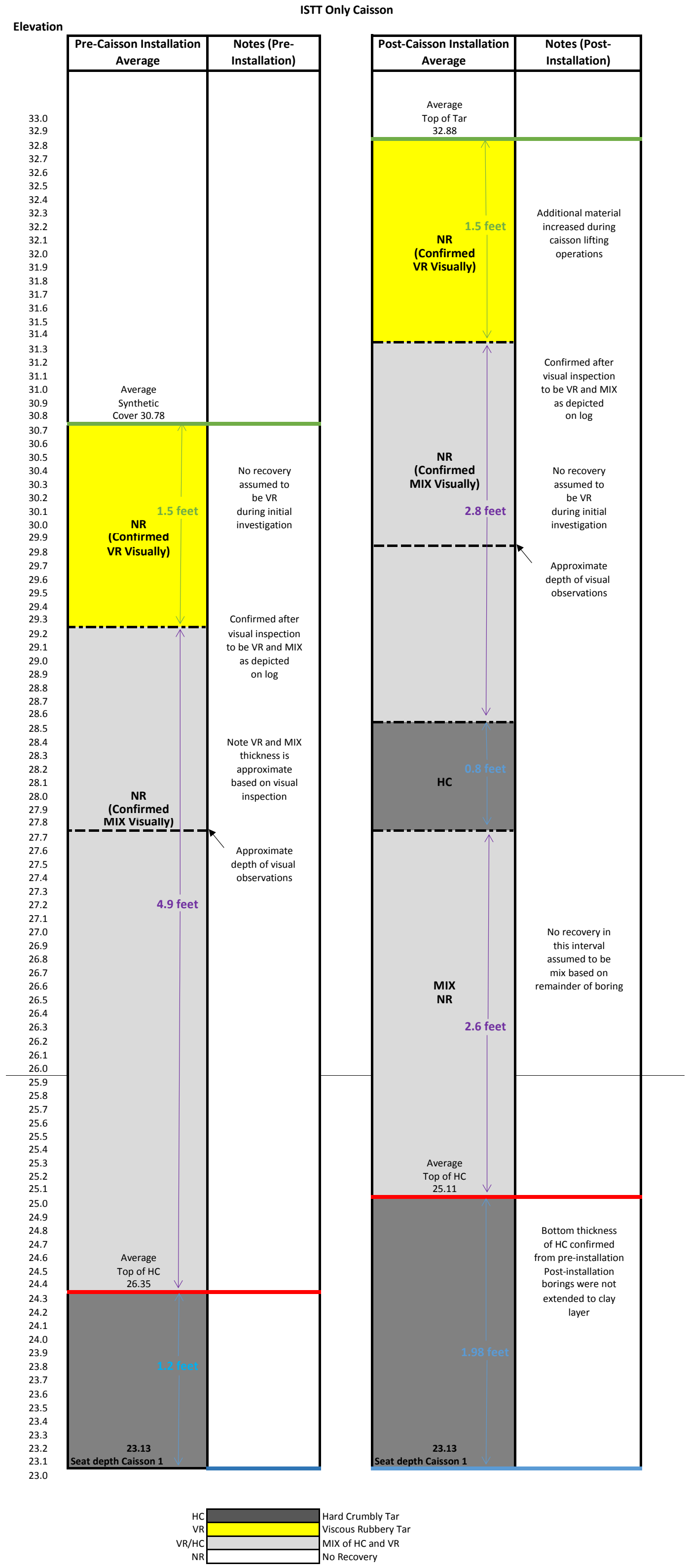

Figure 3

Caisson 3 Profile - Pre- and Post-Caisson Installation Summary

American Cyanamid Superfund Site

OU8 Pilot Testing